

Planck 2015 results: XVI. Isotropy and statistics of the CMB

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Abstract

© 2016 ESO. We test the statistical isotropy and Gaussianity of the cosmic microwave background (CMB) anisotropies using observations made by the Planck satellite. Our results are based mainly on the full Planck mission for temperature, but also include some polarization measurements. In particular, we consider the CMB anisotropy maps derived from the multi-frequency Planck data by several component-separation methods. For the temperature anisotropies, we find excellent agreement between results based on these sky maps over both a very large fraction of the sky and a broad range of angular scales, establishing that potential foreground residuals do not affect our studies. Tests of skewness, kurtosis, multi-normality, N-point functions, and Minkowski functionals indicate consistency with Gaussianity, while a power deficit at large angular scales is manifested in several ways, for example low map variance. The results of a peak statistics analysis are consistent with the expectations of a Gaussian random field. The "Cold Spot" is detected with several methods, including map kurtosis, peak statistics, and mean temperature profile. We thoroughly probe the large-scale dipolar power asymmetry, detecting it with several independent tests, and address the subject of a posteriori correction. Tests of directionality suggest the presence of angular clustering from large to small scales, but at a significance that is dependent on the details of the approach. We perform the first examination of polarization data, finding the morphology of stacked peaks to be consistent with the expectations of statistically isotropic simulations. Where they overlap, these results are consistent with the Planck 2013 analysis based on the nominal mission data and provide our most thorough view of the statistics of the CMB fluctuations to date.

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Keywords

Cosmic background radiation, Cosmology: observations, Methods: data analysis, Methods: statistical, Polarization